RESEARCH HIGHLIGHT

May 2008 Socio-economic Series 08-001

Life Cycle Costing Tool for Community Infrastructure Planning

PROJECT REVIEW

There has been much debate about and investigation into the true costs of different development forms and how costs are shared between public and private sectors.This has resulted in considerable evidence that compact, mixed-use development is more cost-efficient and environmentally sustainable than low-density suburban development. However, there are few readily available tools that can show how much more cost-efficient and environmentally sustainable compact development is. Nor are there readily available tools that effectively compare different types of development.

One reason for this is the lack of data by which a full picture of neighbourhood development costs and revenues, and in particular, costs related to green infrastructure elements can be developed.

In 2002, CMHC commissioned a project to develop a user-friendly costing mechanism to facilitate sustainable community planning by addressing the long-term (75-year) life cycle costs of potential alternative approaches as early as possible in the planning process. The project's ultimate objective was to develop a user friendly tool to determine the most cost-effective planning scenarios at the earliest possible stage with the least possible effort and information.

Phase 1 of the project was research on key costs for development, particularly those costs influenced by urban form. Phase 1 also reviewed available tools for sustainable community planning and outlined a framework for the development of a costing tool. A summary of findings of this phase of the project is in CMHC's socio-economic series as *Research Highlight* number 05-023. "Costing Mechanism to Facilitate Sustainable Community Planning".

Phase 2 of the project was development of a costing tool.

COSTING TOOL OBJECTIVES

The primary purpose of the *Costing Tool* is to enable users to estimate key major costs of community development, particularly those that change with different forms of development (for example, linear infrastructure), and to compare alternative development scenarios.

The *Costing Tool* is geared towards estimating planning level costs and revenues associated with the residential component of a development, although financial impacts of commercial and other types of development can be incorporated if infrastructure requirements are specified. The *Costing Tool* is also designed to allow estimates and comparisons of revenues from development charges, property taxes and user fees.

The *Costing Tool* is designed to analyze medium to large developments (30–1,500 ha [74–3,707 acres]). It can estimate a variety of costs over 75 years, including those related to hard infrastructure, municipal services and some private costs, such as home heating. It can also estimate external costs, such as travel emissions, collisions and climate change.

Estimating green infrastructure costs, such as bike lanes and stormwater harvesting, is an integral part of the *Costing Tool.* Although the *Costing Tool* does not estimate costs of land and actual housing stock directly, these can be entered as user-specified costs.

Ease of use, ease of understanding and relevance to potential users, such as municipalities, planning authorities, developers, consultants and researchers, were considered significant factors in the success of the *Costing Tool.* Representative users from every region of Canada tested and verified the user interface, usability and accuracy. These users then reported through a two-day workshop in Ottawa before the final design completion.

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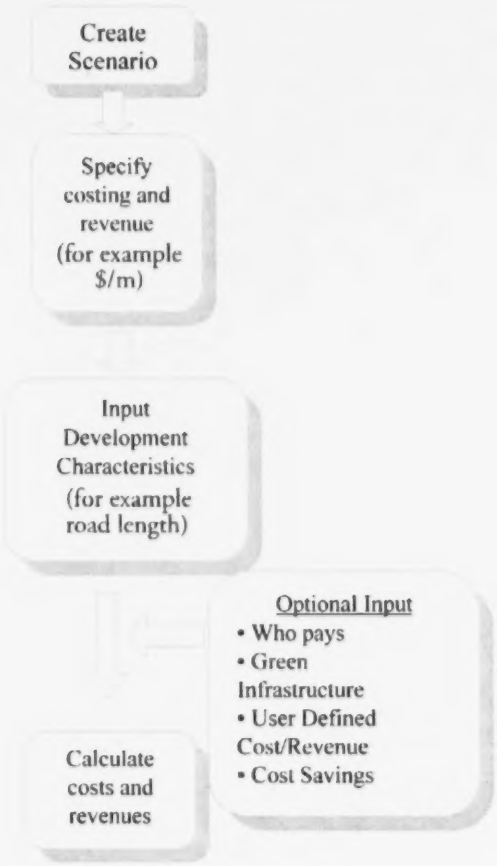

Figure 1 Costing Tool structure

COSTING TOOL STRUCTURE

The *Costing Tool* is a stand-alone Microsoft *Excel*[1] file. The *Costing Tool* is capable of handling, building and storing multiple development scenarios. Figure 1 shows the tool structure and various components. A key feature of the *Costing Tool* is that input, assumptions and calculations are fully visible to users. Users can (and should) modify the *Costing Tool* to suit their specific needs.

Scenarios

A scenario is a unique combination of both development characteristics and costing variables and is the basic structure used for evaluation and comparison. The *Costing Tool* contains six built-in scenarios:

1. A high-density, mixed-use neighbourhood in an inner area.
2. A medium-density, mixed-use neighbourhood in an inner area.
3. A medium-density, mixed-use neighbourhood in an inner suburb.
4. A low-density, residential neighbourhood in an inner suburb.
5. A medium-density, mixed-use neighbourhood in an outer suburb.
6. A low-density, residential neighbourhood in an outer suburb.

Figure 2 is a brief description of these scenarios as they appear in the *Costing Tool* interface.

The purpose of identifying and quantifying alternative scenarios is twofold. Most importantly, the scenarios helped guide the development of the costing framework and ultimately the tool development, ensuring that a range of potential variables and corresponding costs are reflected. In addition, they provide an immediate basis for comparing different types of generic neighbourhood development scenarios.

Factors considered in development of these scenarios include development densities, distance from existing infrastructure, degree of continuity, demographics and planning and service standards.

The built-in scenarios help users learn how to use the *Costing Tool* and illustrate a range of possible inputs. In addition, they provide a basis for user-defined scenarios. Users can create unique scenarios, as there are no constraints on input values.

[1] Excel is a copyrighted software program of the Microsoft Corporation.

Scenario 1

Higher-density Mixed-use Neighbourhood in the Inner Area characterized by:
-Primarily low-rise and high-rise apartments
-Mixed-use development
-Grid road network
-High level of transit service

Scenario 2

Medium-density Neighbourhood in the Inner Area characterized by:
-Mix of townhouses, apartments and single-detached housing
-Mixed-use development
-High level transit service
-Possible brownfield development

Scenario 3

Medium-density Neighbourhood in Inner Suburbs characterized by:
-Mix of townhouses, low-rise apartments and single-detached housing
-Mixed-use development
-Mainly grid road network
-Good level of transit service

Scenario 4

Low-density Neighbourhood in Inner Suburbs characterized by:
-Primarily single-detached with some semi-detached/townhouses
-Primarily single-use (residential) development
-Curvilinear road network
-Moderate transit service

Scenario 5

Medium-density Neighbourhood in Outer Suburbs characterized by:
-Mix of townhouses, low-rise apartments and single-detached housing
-Mixed-use development
-Mainly grid road network
-Good transit service

Scenario 6

Low-density Neighbourhood in Outer Suburbs characterized by:
-Primarily single-detached housing
-Primarily single-use (residential) development
-Curvilinear road network
-Low levels of transit service

Figure 2 The *Costing Tool* built-in scenarios

INPUT REQUIREMENTS

Input variables

The *Costing Tool* is based on a step-by-step process in which development characteristics are entered and other variables are optionally modified. There are three input variables: Costing Variables, Revenue Variables and Development Characteristics. Tables 1, 2 and 3 are detailed breakdowns of the variables.

Table 1 *Costing Tool* costing variables

Category	Cost Type
General cost assumption	Interest rate for amortizing capital costs Cost escalation factor
Hard infrastructure	Roads and local municipal services Regional municipal services Local stormwater management Road operation costs Water treatment and distribution costs Wastewater treatment Sanitary and storm sewers Schools Recreational facilities Transit Fire protection Police services
Municipal services	Waste management Private vehicles Home heating Climate change and air pollution Motor vehicle collisions
Private costs	Local roads External roads
External costs	Water distribution Sanitary sewer
Replacement period for capital assets	Storm sewer Schools Recreational facilities Bus transit Fire and police service vehicles

Table 2 Costing Tool revenue variables

Category	Revenue Type
Development charges	Single-detached Semi-detached Rowhouse Townhouse-Duplex Low-rise High-rise
Property taxes	Average assessment value Property tax rate
User charges	User charges not included in property taxes Transit fare

Table 3 *Costing Tool* development characteristics

Category	Characteristic Type
Land use and location	Distance to central business district Gross land area Per cent residential
Development type	Compact development Medium-density residential development Primarily residential development
	Development Densities
Demographic assumptions	Household size by dwelling type Number of adults per household Average household income Number of jobs
Hard infrastructure	
Transit infrastructure	

Additionally, the *Costing Tool* has the flexibility of incorporating costs and savings of applying green infrastructure alternatives and of acknowledging any existing infrastructure (such as is often the case for brownfield and greyfield developments) as described in the following section.

DISCUSSION OF COSTING VARIABLES

The focus of the *Costing Tool* is on key costs that vary with the urban elements that are usually considered in sustainable community planning. As a result, the types of cost included in the Costing Tool generally include:

- Local and regional capital, operating and maintenance costs for hard services including water supply and transmission, wastewater treatment and transmission, roads and transit, stormwater servicing.
- External–indirect costs including air emissions, auto accidents, congestion, parking, travel time.
- Land area–consumption of land.

Research suggests that the cost of hospitals and education facilities also varies by neighbourhood. The research team found that most of these costs are driven purely by population and the cost per person is relatively constant by neighbourhood. The *Costing Tool* quantifies and includes school costs, while healthcare costs are not considered, because of the complex nature of such costs and the uncertainty of the link between them and urban form.

Land consumption, and its costs, also deserves careful consideration. Land costs are generally passed on directly from the developer to the consumer. There are costs associated with the consumption of land for development (that is, making it unavailable for other uses), but these vary considerably by location and require significant value judgments. As a result, land costs are not estimated explicitly as part of the primary costing model, but users can incorporate land costs if they want.

To develop a full cost-accounting framework the importance of considering the external, non-monetary costs in addition to the conventional monetary costs was recognized. It appears that urban development patterns do influence air pollution and traffic accidents, for example. These costs are based on vehicle ownership and use and are estimated using a sub-procedure, which relied on previous CMHC research.[2]

Green Infrastructure Component

The green infrastructure component of the *Costing Tool* allows the user to explore a wide variety of green infrastructure alternatives and in many cases estimate associated costs and revenues. The term "green infrastructure" refers to all infrastructure components of a development that enhance the environmental sustainability of the development relative to conventional approaches. The intent of this component is to introduce green infrastructure concepts and advise users on how to calculate costs. Green infrastructure alternatives considered in the *Costing Tool* are:

- Bicycle and pedestrian paths;
- Alternative development standards;
- Traffic calming;
- Stormwater management;
- Alternative landscaping;
- Green roofs;
- Tree preservation;
- Building orientation and design.

These alternatives were selected on the basis of available and reliable data and as such they represent only a few of the potential green infrastucture elements. Because of the scarcity of reliable long-term data, there is no dynamic feedback in this component of the Costing Tool. However, users can manually adjust infrastructure assumptions, such as pipe sizes or size of stormwater management ponds.

There is a separate screen for each green infrastructure alternative, with similar layouts, which consist of four sections of "General Description and Importance to Sustainability," "Typical Costs," "Typical Savings" and "Costs." Cost savings from green infrastructure alternatives can also be specified manually. Users are encouraged to explore and manually enter tradeoffs (savings) associated with green infrastructure options.

KEY OUTPUT RESULTS

Summaries of costs and revenues and optional comparisons of different scenarios in various formats are provided as the main output of the *Costing Tool*. Cost comparisons are made on a 75-year life cycle approach and the results are given in five categories:

1. Hard infrastructure, including roads, sewers, stormwater facilities, schools and recreation centres.
2. Municipal services, including transit services, school transit, fire services, police services and waste management services.
3. Private user costs, including driving costs and home heating costs.
4. External costs, including air pollution, climate change and motor vehicle collisions.
5. Green infrastructure alternatives.

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[2] CMHC *Research Highlight socio-economic series* "Greenhouse Gas Emissions from Urban Travel: Tool for Evaluating Neighourhood Sustainability," 2000

Costs are compared to revenues from development charges, property and user fees.

Sample Results

The following are sample results (figure 3) of application of the *Costing Tool*. Figure 4 shows two different scenarios—a conventional suburban development and a neo-traditional development with higher housing densities—which were evaluated for a case study in the Ottawa community of Barrhaven.

Figure 5 is one of the summaries of annual costs per household for the two scenarios.

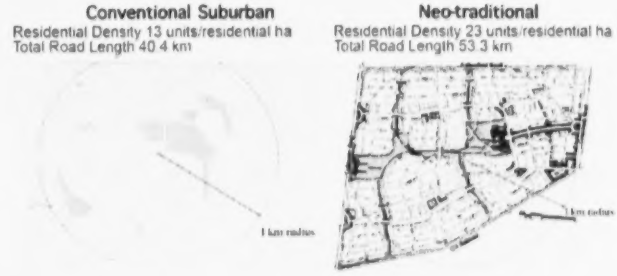

Figure 4 The conventional suburban development and neo-traditional development scenarios

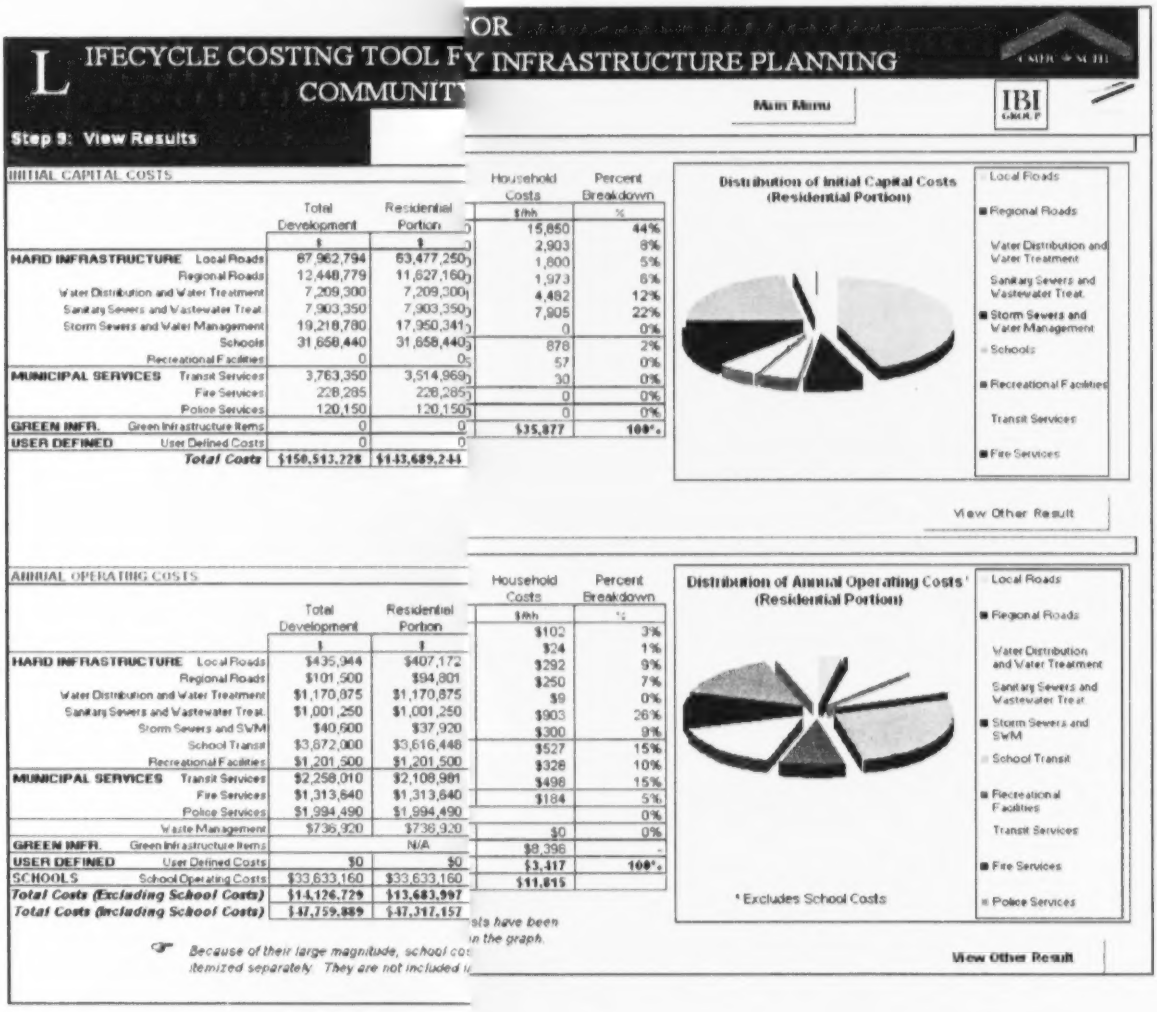
LIFECYCLE COSTING TOOL FOR COMMUNITY INFRASTRUCTURE PLANNING
Main Menu
Step 3: View Results
INITIAL CAPITAL COSTS
Total Development
Residential Portion
Household Costs $/hh
Percent Breakdown %
HARD INFRASTRUCTURE Local Roads $7,962,794 $3,477,250 15,850 44%
Regional Roads $2,448,779 $1,627,160 2,903 8%
Water Distribution and Water Treatment $7,209,300 $7,209,300 1,800 5%
Sanitary Sewers and Wastewater Treat. $7,903,350 $7,903,350 1,973 6%
Storm Sewers and Water Management $9,218,780 $7,950,341 4,482 12%
Schools $1,658,440 $1,658,440 7,905 22%
Recreational Facilities $0 $0 0 0%
MUNICIPAL SERVICES Transit Services $763,350 $514,969 878 2%
Fire Services $228,285 $228,285 57 0%
Police Services $120,150 $120,150 30 0%
GREEN INFR. Green Infrastructure Items $0 $0 0 0%
USER DEFINED User Defined Costs $0 $0 $35,877 100%
Total Costs $150,513,228 $143,689,243
Distribution of Initial Capital Costs (Residential Portion)
Local Roads
Regional Roads
Water Distribution and Water Treatment
Sanitary Sewers and Wastewater Treat.
Storm Sewers and Water Management
Schools
Recreational Facilities
Transit Services
Fire Services
View Other Result
ANNUAL OPERATING COSTS
Total Development
Residential Portion
Household Costs $/hh
Percent Breakdown %
HARD INFRASTRUCTURE Local Roads $435,944 $407,172 $102 3%
Regional Roads $101,500 $94,801 $24 1%
Water Distribution and Water Treatment $1,170,875 $1,170,875 $292 9%
Sanitary Sewers and Wastewater Treat. $1,001,250 $1,001,250 $250 7%
Storm Sewers and SWM $40,600 $37,920 $9 0%
School Transit $3,872,000 $3,616,448 $903 26%
Recreational Facilities $1,201,500 $1,201,500 $300 9%
MUNICIPAL SERVICES Transit Services $2,258,010 $2,108,981 $527 15%
Fire Services $1,313,640 $1,313,640 $328 10%
Police Services $1,994,490 $1,994,490 $498 15%
Waste Management $736,920 $736,920 $184 5%
GREEN INFR. Green Infrastructure Items N/A $0 0%
USER DEFINED User Defined Costs $0 $0 $9,396 -
SCHOOLS School Operating Costs $33,633,160 $33,633,160 $3,417 100%
Total Costs (Excluding School Costs) $14,126,729 $13,683,997 $11,815
Total Costs (Including School Costs) $47,759,889 $47,317,157
Distribution of Annual Operating Costs* (Residential Portion)
Local Roads
Regional Roads
Water Distribution and Water Treatment
Sanitary Sewers and Wastewater Treat.
Storm Sewers and SWM
School Transit
Recreational Facilities
Transit Services
Fire Services
Police Services
* Excludes School Costs
Because of their large magnitude, school costs have been itemized separately. They are not included in the graph.
View Other Result

Figure 3 Sample result page from *Costing Tool*

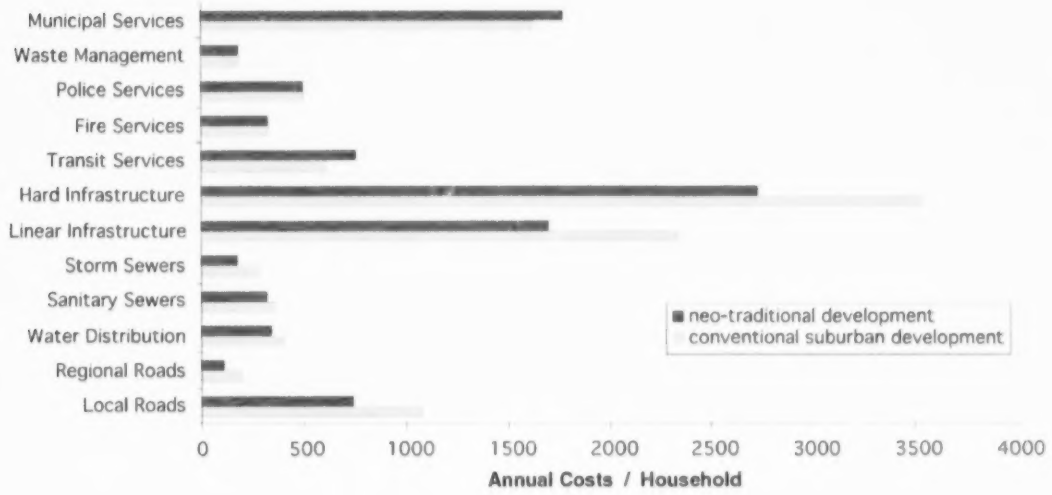

Figure 5 Comparison of annual costs per household for the two scenarios

Results show that for most of the cost categories, the neo-traditional households are estimated to have a lower annual cost than the conventional development. Hard infrastructure and linear infrastructure costs show the highest degree of reduction, at 25 per cent less cost. On the other hand, the municipal costs—such as fire, police and waste management—that are more directly proportional to population, not density of development, are similar in both scenarios.

POTENTIAL APPLICATIONS FOR THE COSTING TOOL

The *Costing Tool* can be used by municipalities, planning authorities, developers, consultants and researchers to evaluate and compare multiple scenarios as part of their early investigation into the most sustainable options.

CMHC has, for example, used the costing tool in sustainable community planning charrettes across Canada for projects such as:

- A new, 20-Ha (50-acre)mixed-use development in Strathcona, Alberta.
- The Saline Creek Plateau, a 860-ha (2,125-acre) mixed-use expansion area in Fort McMurray, Alberta.
- The 250-ha (618-acre) mixed-use Porter Creek Bench expansion area in Whitehorse, Yukon.
- A 57-ha (141-acre) mixed-use development on a golf course in Montréal.

Sequencing with other costing tools

The *Costing Tool* is designed to fit within the hierarchy of other sustainable community planning tools.

MetroQuest software is a well-known interactive planning support tool that evaluates alternative future scenarios for urban and regional planning at the macro level. It can inform decisions on community planning, which could then be refined using the CMHC *Costing Tool*.

InfraCycle is a site-specific cost/revenue analysis tool which can analyze detailed scenarios after they are identified with the CMHC tool.

Costing Tool Limitations

The *Costing Tool* comes with some limitations.

- The *Costing Tool* is primarily intended for residential developments. As a result, the input categories do not facilitate the Costing Tool being used for certain types of developments, such as pure commercial and industrial, although it does recognize mixed-use development.
- Application of the *Costing Tool* in different regions should also be done with caution as costing variables vary with local circumstances and time. Cost comparisons are always valid when scenarios are compared on the same basis but actual dollar costs may not be accurate unless local costs are entered to replace the default costs built into the tool.
- Users of the *Costing Tool* may face initial difficulty in exploring the various input and output choices. This complexity of the issue and thus the software is somewhat inevitable given the wide range of variables incorporated. However, the tool is readily shared and various members of a design team can input into those aspects of the tool with which they are the most familiar. Once such initial input is completed it would remain as the default information and subsequent analysis would take a matter of minutes by any one designer.
- Green infrastructure costs, savings and trade-offs are notional and require some judgment by the user.

CONCLUSIONS

Solutions to achieve more sustainable communities have been gaining prominence in the development industry in recent years. It is now well understood that effective sustainable community planning necessitates the integration of many issues into each decision and solution. This, in turn, means that individuals can only rarely make well-informed decisions without the proper support of tools and/or other experts.

The *Life Cycle Costing Tool for Community Infrastructure Planning* has proven to be an efficient and effective tool by which one individual or a team can quickly and effectively assess and quantify a broad range of costs of numerous infrastructure options as integrated scenarios and demonstrate their long-term cost effectiveness.

As this can be done with minimal information at a very early planning stage when course corrections are still possible the outputs can be used to gain and guide municipal support for alternate approaches when it is most critical. This means that alternate, more sustainable, planning directions have a greater chance for identification, implementation and success with the use of the Costing Tool.

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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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